International Journal of Advanced Engineering, Management and Science (IJAEMS)
Peer-Reviewed Journal
ISSN: 2454-1311 | Vol-9, Issue-9; Sep, 2023
Journal Home Page: https://ijaems.com/
Article DOI: https://dx.doi.org/10.22161/ijaems.99.8

Study the effect of Industrial Dairy and Textile Waste Water on the Engineering and Geotechnical Properties of Fine-Grained Soil

Elsayed A. El Kasaby, Alnos A. Eissa, Alaa F. Essa

Dep. of Civil Eng. Faculty of Engineering, Banha University, Egypt

Received: 12 Aug 2023; Received in revised form: 15 Sep 2023; Accepted: 22 Sep 2023; Available online: 30 Sep 2023

***Abstract*— *Understanding and prediction of engineering properties of fine-grained soils is of vital importance in Geotechnical Engineering practice. Fine-grained soil contamination occurs on a daily basis as a result of industrial development and pipeline or reservoir leaks.Due to the influence of the surrounding condition, substantial damage occurs in the foundations of buildings. The presence of industrial wastewater in the soil contributes to a change in its physical, chemical and mechanical properties, and then negatively affects the foundations of various facilities. . In addition to environmental issues such as groundwater contamination, the changing of the geotechnical qualities of polluted soil is a concern. As a result of the concentrations of pollutants resulting from the businesses such as Dairy products industry and spinning and weaving factories, are extremely high in developing countries. Disposal of untreated industrial waste water is a common problem in these countries. This paper describes an experimental investigation that was conducted to explore the effect of two types of industrial waste water the first type was dairy industrial waste water (DW) and the second was textile industrial waste water (TW) on the deformational behavior of fine-grained soil. Fine-grained soil used in this research was obtained in a natural phase from a soil excavation site for the construction of a residential building in the village of El-Kom Al-Ahmar, Shibin El-Qanater, Qualiobiyah governorate Fig.1, which was exposed to DW and TW at 2, 4, 6, 8, 12, and 16 months, Two remolded soil samples are generated for this investigation and combined with different types of industrial wastewater of constant moisture content (70%). The Atterberg limits, plasticity index, specific gravity, free swelling, optimal moisture content (OMC), and maximum dry density (γdmax) of each mixture were calculated after 0, 2, 4, 6, 8, 12, and 16 months of mixing soil with industrial waste water, the results revealed that as soil matures, the optimum moisture content (O.M.C) and free swelling values of the soil containing DW, TW rise after the addition of pollutants, whereas the maximum dry density, specific gravity (GS), and cohesiveness decrease.*

Keywords*— *Fine-grained soil. Contaminated soil. Industrial waste water. Geotechnical properties.

I. INTRODUCTION

Soil pollution stemming from a variety of industrial wastewater byproducts stands as a significant geo-environmental concern, adversely affecting soil quality, groundwater, and the atmosphere. The acceleration of industrialization and urbanization has generated substantial quantities of both solid and liquid waste, consequently leading to extensive alterations in the geotechnical characteristics of soil due to the disposal of wastewater into the ground, as noted in reference [1-2]. Incidents of foundation and structural failures attributed to soil contamination and chemical spills have been documented in several reports [3, 4]. Extensive research has shown that various geotechnical properties of fine-grained soils can be influenced by both inorganic and organic contaminants typically present in industrial effluents [5, 6, 7]. To address the needs of diverse engineering applications, it is essential to thoroughly investigate and comprehend the interactions between soil and pollutants, as well as the repercussions of pollutants and industrial effluents on various geotechnical characteristics.

A comprehensive examination of the existing body of literature reveals that, to date, the primary emphasis has been on comprehending how pure chemicals affect commercial soils such as kaolinite and bentonite. There is comparatively limited research available regarding the effects of industrial effluents, especially on natural soils [8,9].

Industrial wastewater can contain hazardous substances that are relatively water-soluble, with examples including those originating from textile, dairy, and leather waste. The contamination of industrial wastewater poses significant risks to wildlife, including the poisoning of apex predators that consume organisms with accumulated wastewater in their tissues [10,11]. This contamination can disrupt breeding patterns by making animals ill and unable to reproduce. It can also lead to skin, mouth, or nasal irritation or ulceration, damage red blood cells, and harm the adrenal tissue of birds, impairing their ability to defend against predators [12].

The hormonal equilibrium in birds can also be disrupted through exposure to industrial effluents, potentially influencing factors like luteinizing protein. Despite comprehensive research on the geotechnical attributes of polluted fine-grained soils, there has been limited investigation into the impact of wastewater pollution on the geotechnical properties of such soils [11, 13].

Khan et al. (2017), Stalin et al. (2010), and Easa et al. (2002) have all conducted laboratory testing programs aimed at assessing the influence of wastewater contamination and the aging process on the geotechnical properties and behavior of fine-grained soil [1,6,8]. In Easa et al.'s (2010) study, samples of naturally contaminated groundwater sourced from household wastewater were obtained at the groundwater pumping level. The assessment involved the use of X-ray and conventional chemical testing to determine the concentration of toxins present in the groundwater [14]. The research findings suggest that residential wastewater is considered the predominant source of groundwater pollution due to its extremely hazardous and toxic chemical composition [15,16]. This contamination poses a substantial threat to public health. Additionally, a separate study highlighted the capacity of clay to expand as a result of fluctuations in water content, which can be induced by groundwater, leading to upward pressure on foundations. The expansion of clay and the resulting swelling pressure can result in substantial damage, including the cracking of walls, beams, and columns, particularly when the soil's swelling pressure exceeds the foundation load [17,18,19].

The thorough prediction of soil geotechnical parameters is a critical practice in geotechnical engineering, particularly in the presence of contamination [20]. Soil characteristics are altered as a result of ground pollution, Soil property changes cause a variety of geotechnical issues such as structural cracks, ground settlement, heaving of structures, slope instability, depletion of strength and deformation characteristics, changes in compaction characteristics, and so on.

Previously, the adequate attention of construction damages were attributed to many factors such as inadequate construction material, differential settlement, the destructive role of expansive and collapsing soil, etc. While, the effect of waste water on soils was taken as second or third reason of building and construction problems [8].

Recently, progressive increasing of constructions damage caused due to effect of waste water on soil was reported by engineers and investigations [21-24]. So, engineers are concerned about the amount of damage caused by waste water to buildings, foundations, and soils.

On the other hand, if the chemical composition of the water in the pores of the clay is changed, the physical and mechanical properties of the clay are expected to change. Thus, the pore fluid type and composition strongly affects the engineering behavior of most soils especially clayey soils [25-27].

Furthermore, several investigations have shown that, the pollution of soil has important influence on the physical and mechanical properties of clay [28, 29].

Hence, modern building necessitates not only a prior examination of the foundation material, but also a complete understanding of the processes that cause the changing of soil qualities over the life of the structures supported by it. Several case studies of soil contamination with industrial pollutants and their impact on soil geotechnical behavior are presented below.

Kirov (1989) observed the influence of wastewater on deformation behavior of clayey soil, He found that soils interacting with a solution of detergents undergo a large amount of deformation. Srivastava et al. (1992) observed increase in consistency limit, permeability and coefficient of compression and decrease in shear strength and bearing capacity of a soil specimen permeated with fertilizer plant effluent[29,30].This is due to decrease in cation content and increase in hardness of leaching water after interaction Decrease of liquid limit and plasticity index of montmorillonite soil due to addition of pharmaceutical effluent to the soil has been found due to decrease of dielectric constant by contamination. Yaji et al. (1996) have investigated the influence of sugar mill liquid wastes on the behavior of shedi soil. At large percentages of sugar mill liquid wastes, shear strength decreases [31].

Generally, industrial wastes contain acids, alkalis, sulphates, salts, urea (amides), and oil pollutants, which cause changes in the physicochemical, mechanical and geotechnical properties of the soil.

II. PROPBLEM DIMENSION

In view of modern state tendencies, industrial development occupies an important place for self-sufficiency inside Egypt. Therefore, the government has paid attention to the industrial sector in recent decades. Therefore, the danger arises from industrial wastewater, which poses a real threat to the soil, groundwater, and the mechanical behavior of fine-grained soil. Therefore, the effect of industrial wastewater as a result of the dairy and textile factories scattered in Egypt on fine-grained soil has not been studied. Therefore, the researchers try to identify the properties of contaminated soil to avoid potential risks and also to use contaminated soil beneficially in civil engineering projects. Accordingly, the results of this research can be used in the first phase of the development program studies.

III. EXPERIMENTAL APPLICATION

According to a comprehensive review of the literature, studies on the influence of dairy and textile effluent on natural soils are infrequent or scarce. The wastewater used in this case originated from two separate sources. The first originated from Dairy factory in Minya Governorate , and the second from Textile factory in Obour City, Qalyubia Governorate . These potentially hazardous wastewaters, whose environmental consequences necessitate continuing monitoring, were collected after solids deposition but before treatment. According to a critical review of the literature, considering the foregoing, the two types of industrial wastewaters—dairy and textile wastewater—which are referred to as DW and TW, respectively, in this research—were chosen for the current investigation. Fine-grained soil used in this research was obtained in a natural phase from a soil excavation site for the construction of a residential building in the village of El-Kom alAhmar, Shibin El-Qanater, Qualiobiyah governorate (Fig. 1).

Fig. 1. Site of soil sample

The various effluents in "as collected form" as well as the outflow from the experimental setup, i.e., pH, alkalinity, total solids, total dissolved solids (TDS), total volatile solids (TVS), chloride, and biochemical oxygen demand (BOD) were estimated to be characterized by the effluent parameters. The metrics are complete and adequate for describing the effluent and understanding its impact on the specified soils. The parameter analysis method was carried out in accordance with Standard Methods. The properties of dairy and textile effluent are listed in Table 1. Representative soil samples from the chosen regions were collected in 50 kilograms airtight polythene bags, transported to the lab, and stored in airtight containers under normal conditions. Until usage, keep at laboratory temperature.

Table 1 Physical properties of wastewater (DW1 and TW1)

Properties	**Value**	
	DW	**TW**
Color	light yellow	greenish grey
Temperature (C)	22	24
PH (Value)	10.3	11.80
Total Suspended Solids (TSS), (mg/liter)	2772	2684

Table 2 Organic properties of wastewater (PW and LW)

Properties	**Value**	
	DW	**TW**
Volatile Suspended Solids (VSS)	985	1217
Biological Oxygen Demand (BOD)	686	912
Total organic carbon (TOD)	284	448
Chemical Oxygen Demand (COD)	4513	3876
Oil &Grease	174	266
Phenol	8.5	9.7
Detergents	17.5	22.4
Pesticides	2.4	7.5

Table 3 Chemical properties of wastewater (DW and TW)

Properties	**Value (mg/liter)**	
	DW	**TW**
Chloride (Cl-)	2942	1968
Sulfate (SO42-)	757	3827
Alkalinity (CaCO3)	176	868
Ammonia (NH3-N)	65	162
Phosphate (SO43-)	4.5	17.7

Table 4 Chemical minerals of the samples DW and TW.

Properties	**Value (mg/liter)**	
	DW	**TW**
Aluminum	0.2	0.40
Chromium	1.05	1.80
Copper	0.05	1.70
Iron	2.45	0.55
Lead	0.11	1.25
Manganese	1.80	7.2
Nickel	0.02	2.73

Borne	0.06	4.82
Selenium	0.12	0.58
Fluoride	10.85	8.73
Zinc	0.00	3.70
Arsenic	0.07	0.11
Cyanide	0.01	1.87
Mercury	0.001	0.057
Cadmium	0.03	0.063

3.1 Experimental Set-up and Soil Sample Preparation

This study's experimental design includes two groups, each with six contaminated soils (DW or TW) and natural soil for comparison. These groups were constructed after mixing and according to the timeline Fig. 2.A and B. Each set of soils under consideration was generated and used for the following purposes:

(i) Samples were collected from the site and stored in the laboratory Fig. 2.

(ii) Since each effluent was utilized to investigate how industrial waste materials affected the mechanical and geometric qualities of soil at different ages. As a result, only two sets of polluted soils were used for research purposes. At 2, 4, 6, 8, 12, and 16months, commercial soils were tested.

(iii) A total of 13 samples were used to study the influence of two effluents (DW and TW) on natural soil (S1). A 2.9-kilogram soil sample is manually mixed with effluents at their optimal moisture content (OMC) before being transported.

Scanning electron microscopes (SEM) and X-ray diffraction (XRD) were also utilized to examine the mineral compositions of natural and polluted samples [12-16]. These techniques are available at Egypt's Egyptian Mineral Resources Authority's Central Laboratories Sector's Housing & Building National Research Centre in Giza. The experimental program was developed in order to determine the swelling behavior of the tested soils In addition to tests for liquid limit (L.L), plastic limit (P.L), shrinkage limit (S.L), specific gravity (GS), and finally the standard Proctor test. As shown in (Fig. 3.A, B and C), (Fig.4.A and B).

Fig. 2. Sample preparation with the contaminated industrial wastewater.

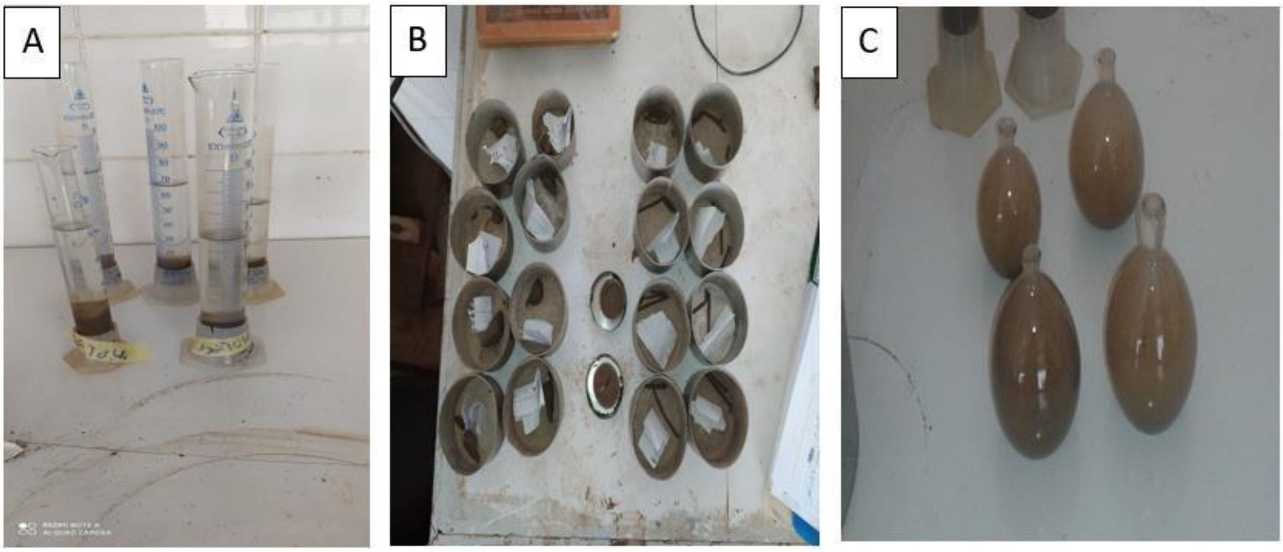


Fig.3. Preparing soil for free swell (F.S), (L.L), (P.L), (S.L) and (GS) tests

Fig.4.standard Proctor test

IV. RESULTS AND DISCUSSION

4.1 Physical Properties

Tables 5 and 6 list the index parameters of natural (S1) and contaminated soil, including specific gravity and Atterberg limits (liquid limit (LL), plastic limit, shrinkage limit (SL), and plastic index). According to these findings and the unified soil classification system (USCS):

i) The natural soil's liquid limit (LL) and plastic limit (PL) values were 74% and 33%, respectively. While the relative levels of contamination (LL and PL) of soil with dairy effluent are, respectively, 66.5% to 62% and 32% to 27%. The LL and PL of soil contaminated with textile wastewater ranged from 62% to 63% and 34.5% to 33%, respectively, and PI of TW and DW contaminated soil are range of 41%, to30%, and 41% to 35% respectively.

ii) The specific gravity (GS) and shrinkage limit (SL) of natural soil were 18% and 2.67, respectively. While the specific gravity (GS) and (SL) of soil that has been contaminated with dairy effluent range from 2.6 to 2.56 and 19% to 21%, respectively. The specific gravity (GS) and (SL) of soil contaminated with textile effluent were2.65 to 2.6 and 19.2% to 20.5%, respectively.

Table 5. The results of Atterberg limits for natural and contaminated soil with DW at different times (months)

Property	**(natural soil)**	**S1**	**DW1 (2 month)**	**DW2 (4 month)**	**DW3 (6 month)**	**DW4 (8 month)**	**DW5 (12 month)**	**DW6 (16 month)**
G. S	2.67		2.6	2.6	2.58	2.577	2.57	2.565
Atterberg limits	(L.L), %	74	66.5	65	64	63	62.5	62
	P.L	33	32	30	29	28	27	27
	S.L	18	19	20	21	Broken	Broken	Broken
	P.I	41	36.5	35	35	35	35	35
USCS	MH		MH	MH	MH	CH	CH	CH

Table 6. The results of Atterberg limits for natural and contaminated soil with TW at different times (months).

Property		**(natural soil)**	**TW1 (2 month)**	**TW2 (4 month)**	**TW3 (6 month)**	**TW4 (8 month)**	**TW5 (12 month)**	**TW6 (16 month)**
G. S		2.67	2.65	2.635	2.63	2.61	2.61	2.6
Atterberg limits	(L.L), %	74	62	62	62.5	63	63	63
	P.L	33	34.5	35	35.5	35	34	33
	S.L	18	19.2	20.5	20.5	broken	broken	broken
	P.L	41	27.5	27	27	28	29	30
USCS		**MH**	**MH**	**MH**	**MH**	**CH**	**CH**	**CH**

4.2 Compaction Outcomes

The compaction test results for the natural soil and contaminated soils at different dates are shown in Figs.5.and Fig6. It is clear from Table 6, which includes the compaction findings as maximum dry density (γdmax) and optimum moisture content (OMC), that:

i) The optimum moisture content (O.M.C.) and maximum dry density (γdmax) of natural soil (S1) were 20% and 1.70 gm/cm3, respectively, while these values ranged from 22.5% to 24% and 1.61 to 1.53 gm/cm3 for soil that had been contaminated DW. When soil was contaminated with TW effluent, the O.M.C. and dry density were, respectively, 20.5% to 22.3% and 1.65 to 1.6 gm/cm3.

ii) The (γdmax) of both contaminated soils was lower than that of the natural soil. The γdmax of DW-contaminated soil is lower than TW-contaminated soil.

Table 7. Compaction out comes for the studied soils

Sample No	**Sample No**	**O.M.C, %**	**γdmax., t/m3**
Natural Soil	S1	20	1.7
Contaminated soil with DW	DW1 (2 month)	22.5	1.61
	DW2 (4 month)	22.75	1.6
	DW3 (6 month)	23	1.58
	DW4 (8 month)	23.5	1.57

	DW5 (12 month)	24	1.54
	DW6 (16 month)	24	1.53
Contaminated soil with TW	TW1 (2 month)	20.5	1.65
	TW2 (4 month)	21	1.64
	TW3 (6 month)	21.5	1.62
	TW4 (8 month)	21.75	1.61
	TW5(12 month)	22	1.6
	TW6(16 month)	22.3	1.6

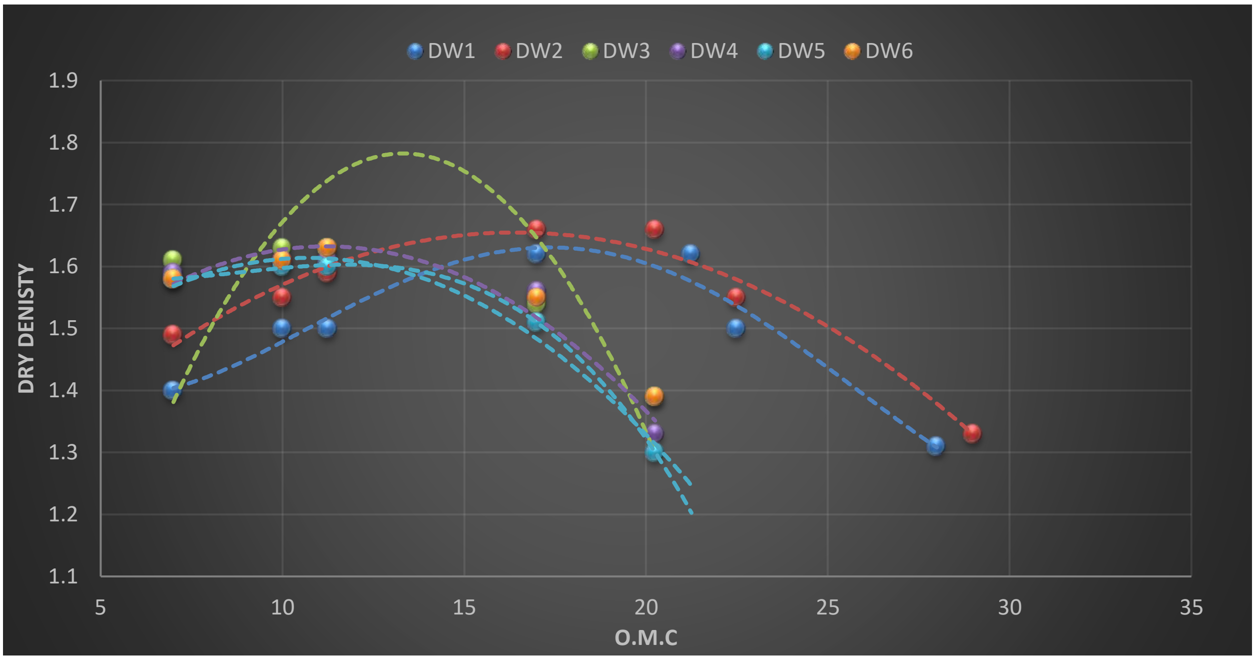


Fig.5. Results of standard proctor test curves for contaminated soil with DW.

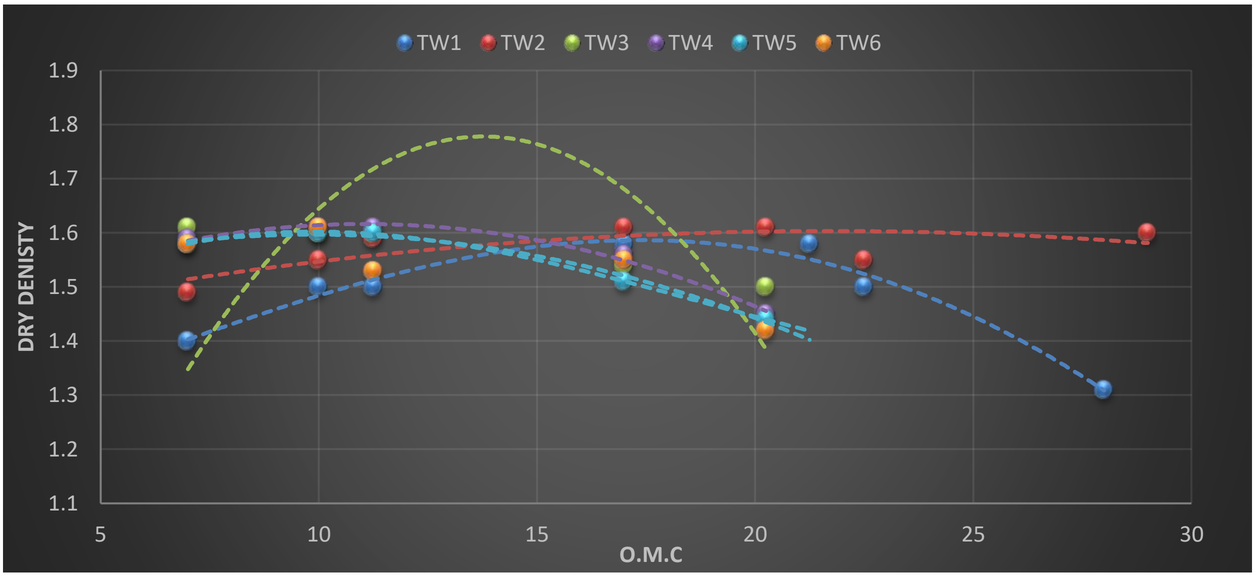


Fig.6. Results of standard proctor test curves for the contaminated soil with TW.

4.3 Swelling Results

Free swell is an increase in soil volume caused by immersion in water without any external restrictions. An assessment of those soils considered to exhibit unwanted expansion characteristics is necessary to determine the risk of harm to structures caused by the swelling of pricey clays. To reflect the system's ability to expand under various simulated scenarios, inferential testing is used. The dry density, starting water content, surcharge loading, and various other environmental parameters all affect how much swelling pressure develops. As a result, Table 7 contains a list of the free swell (F.S) results. The relationship between the percentage of free swell (F.S.) and the dry density's ideal water content (O.M.C.) is shown in Fig 7 to 8. Respectively, the liquid limit (L.L), plasticity index (P.L), and shrinkage limit (S.L). Additionally, it should be emphasized that: According to the findings of free swell regarding the connections of F.S with physical qualities (O.M.C, L.L, P.I, and S.L).

i) The free swell (F.S.) values range from 60% for the natural soils. The results showed that S1 (natural soil) has the lowest value (60%) and DW5, DW6 (12 and 16 months) has the highest value (78%). The results of the swelling show that as wastewater ages, the value of the swelling rises, and The F.S of TW-contaminated soil at TW6 (16 months) has highest value (79.5%).

ii) The F.S of DW-contaminated soil was lower than that of The F.S of TW-contaminated soil.

II) The swelling DW and TW-contaminated soil increases with the ageing increases.

Table 8. Swell results for the studied soils

Sample No	Sample No	F.S, %	Remarks
Natural Soil	**S1**	**60%**	The Swelling Increases with the ageing increases
Contaminated soil with DW	DW1 (2 month)	65%	
	DW2 (4 month)	72.5%	
	DW3 (6 month)	75%	
	DW4 (8 month)	76%	
	DW5 (12 month)	78%	
	DW6 (16 month)	78%	
Contaminated soil with TW	TW1 (2 month)	70%	
	TW2 (4 month)	72%	
	TW3 (6 month)	75%	
	TW4 (8 month)	76.5%	
	TW5(12 month)	77.5%	
	TW6(16 month)	79.5%	

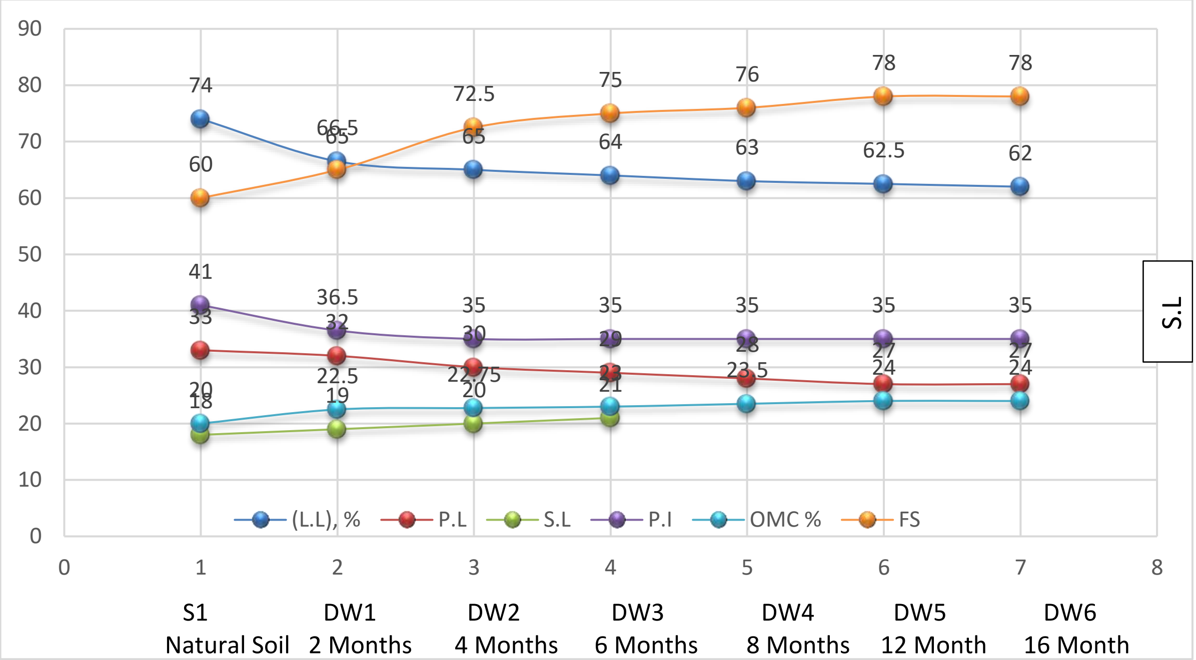


Fig. 7. Correlations of Free Swell with Plastic index, Shrinkage Limit, liquid limit and OMC% for (DW).

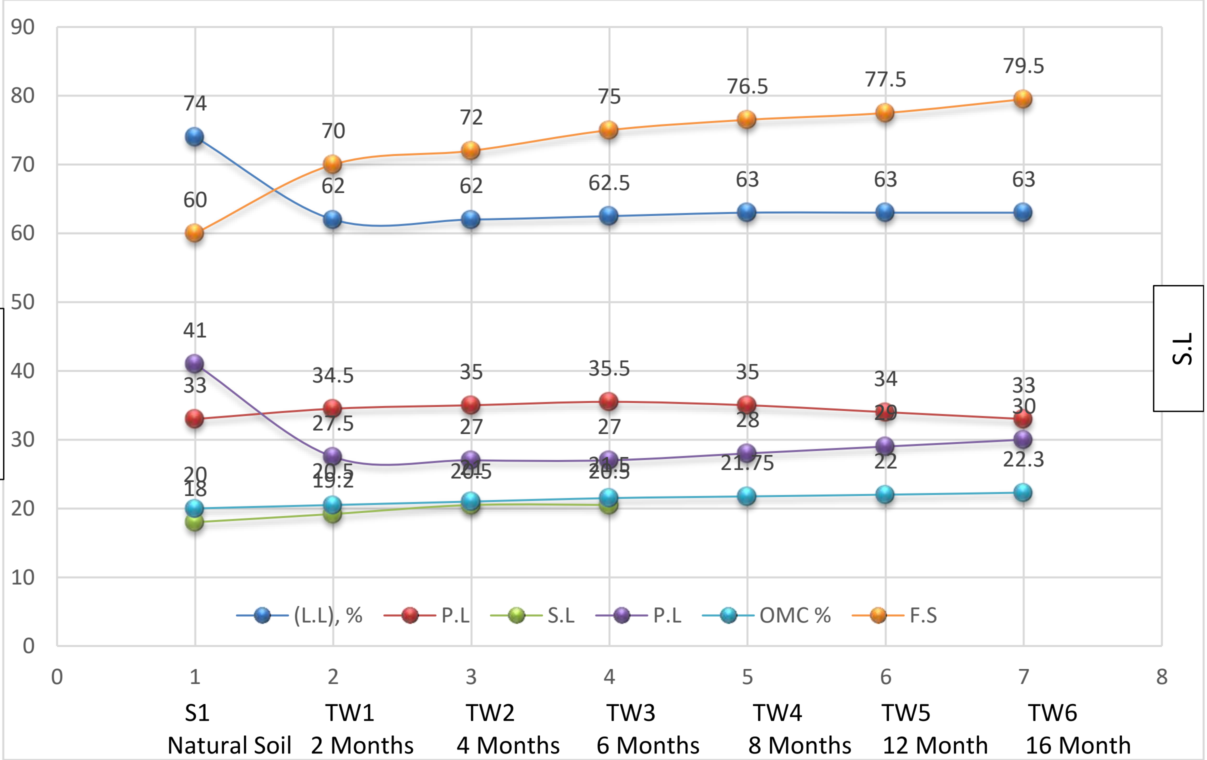


Fig. 8. Correlations of Free Swell with Plastic index, Shrinkage Limit, liquid limit and (OMC%) for(TW) soil.

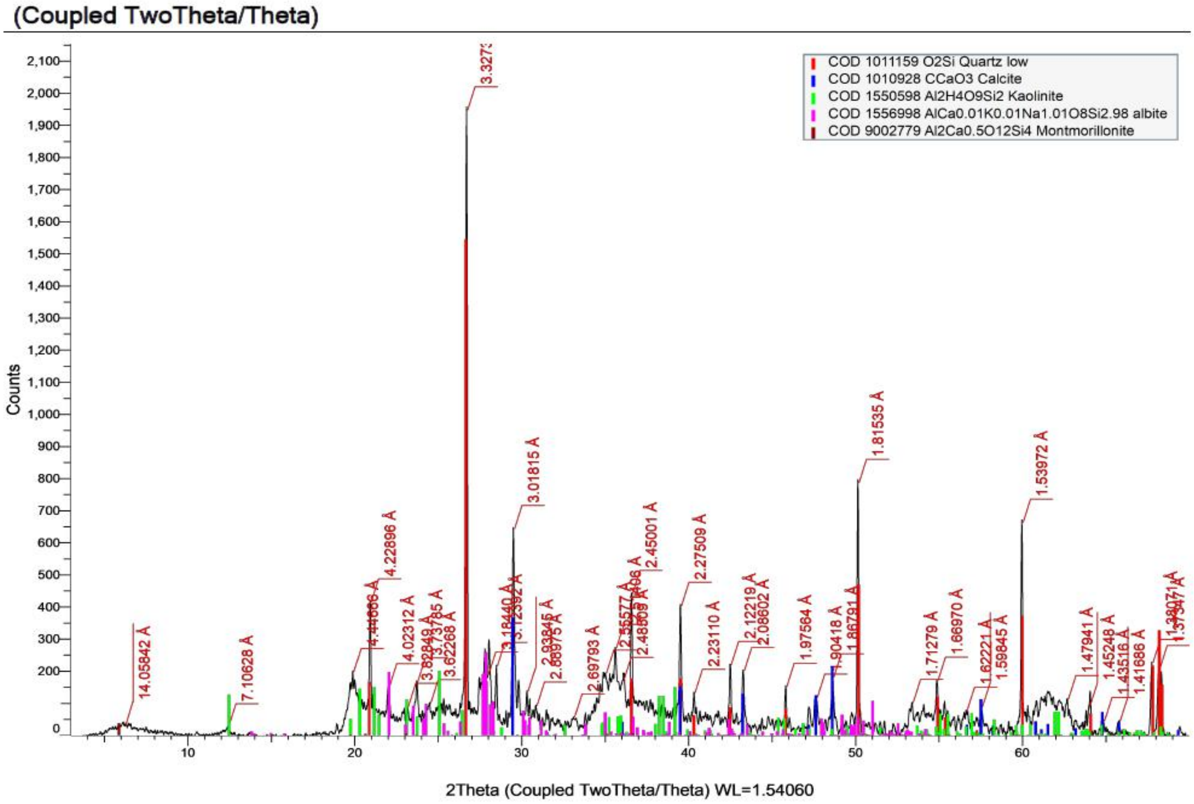
4.4 Mineralogical Analysis of the Tested Soil

To identify the fine-grained soil features found in the study area and to look into differences in mechanical characteristics as a result of the study of the impact of various types of water on the examined soil, laboratory tests were conducted. The experimental program, (Fig9), is based on classification tests (particle size distribution analysis and index test), direct and ring shear tests, and tests on intact, degraded, and reconstituted specimens. By using X-ray diffraction (XRD) and X-ray fluorescence spectroscopy (XRF), 3 samples of fine-grained soil were examined. The X-ray diffraction patterns of natural soil sample, DW and TW samples are shown in (Fig9.a.b and c.)

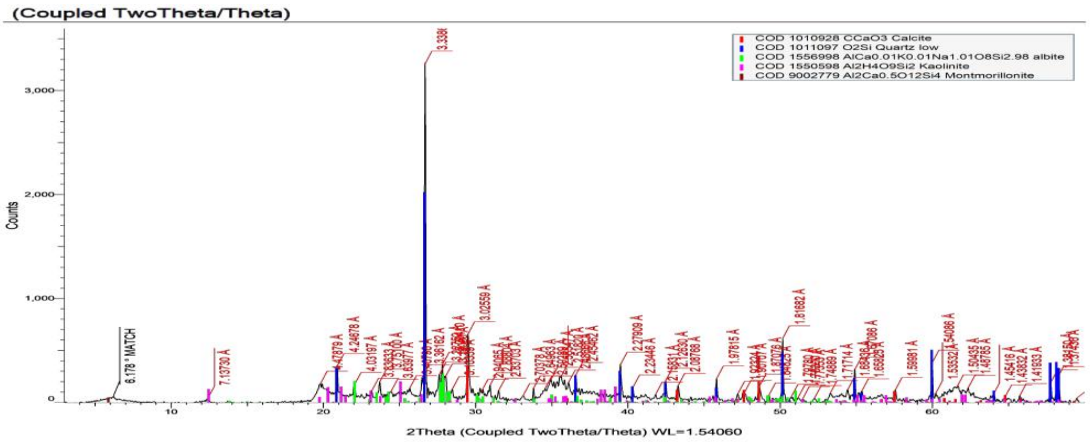
As a result,

Table 9 presents the calculated mineral percentages.

Formula	**S-Q**
O2Si	20.4%
CCaO3	12.8%
Al2H4O9Si2	20.8%
AlCa0.01K0.01Na1.01O8Si.98	22.6%
Al2Ca0.5o12Si4	23.4%

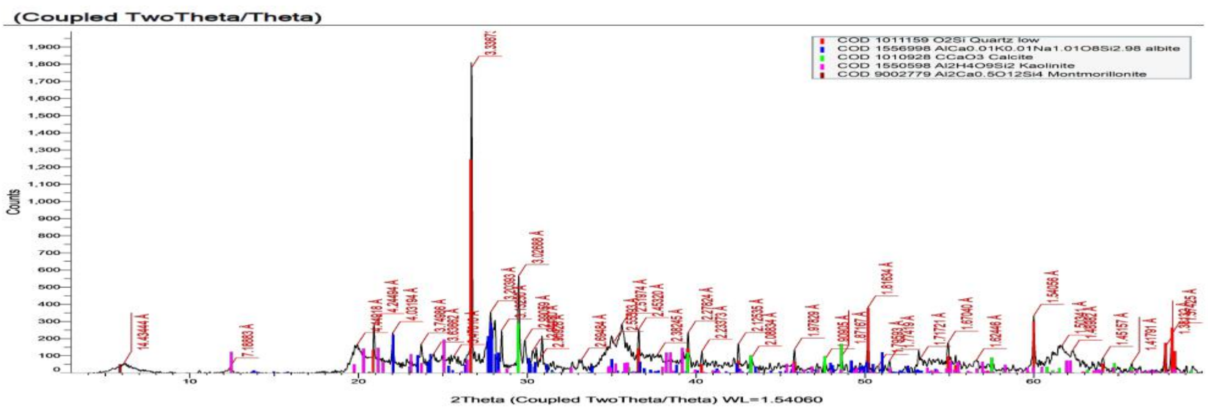


a) Natural sample (S1)



Formula	S-Q
O2Si	12.4%
CCaO3	14%
Al2H4O9Si2	21.3%
AlCa0.01K0.01Na1.01O8Si.98	26.8%
Al2Ca0.5o12Si4	25.5%

b) Soil contaminated with dairy wastewater (DW).



Formula	S-Q
O2Si	11.5%
CCaO3	16%
Al2H4O9Si2	20%
AlCa0.01K0.01Na1.01O8Si.98	22.5%
Al2Ca0.5o12Si4	30%

c) Soil contaminated with textile waste water (TW).

Fig.9. XRD results of the studied soil.

Table9. XRD semi-quantitative percentages results.

Sample No.	Quartz	Calcite	Kaolinite	albite	Montmorillonite
Natural soil	20.4	12.8	20.8	22.6	23.4
DW	12.4	14	21.3	26.8	25.5
TW	11.5	16	20	22.5	30

4.5 Scanning Electron microscopy Investigations (SEM)

The particle structure of the soils and industrial wastewater was compared using scanning electron microscope (SEM) research. Fig.10, 11 and 12. show how the morphology of the tested soils is presented. , . Fig.10. the micrographs of natural soil devoid of industrial waste water, displays scanning electron micrographs of uncontaminated natural soil. The unique characteristics of natural soil, such as its high clay content, are highlighted by the stark variations in soil micrographs of natural soil before contamination. It is possible to see the impact of DW and TW on natural soil by contrasting the micrographs displayed in Fig 10, 11 and12. When compared to natural soil, the microstructure of the contaminated soil particles was looser, more porous, and had a different surface shape. Fig.11, 12. Illustrates the impact of industrial wastewater on natural soil. Sulphate activity causes disaggregation and the removal/washing out of constituents, strengthening the voids in some areas while causing aggregation and changes in the surface texture of the soil mass in other areas. The presence of clay is to blame for this. Mycelium fibers that have been discarded can be observed in a disintegrated and shattered shape in the micrographs in Fig11, 12.

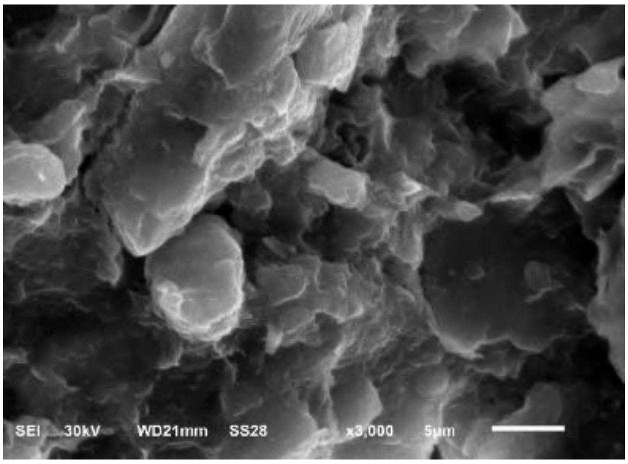


Fig.10. SEM micrograph of natural soil before artificial contamination with wastewaters

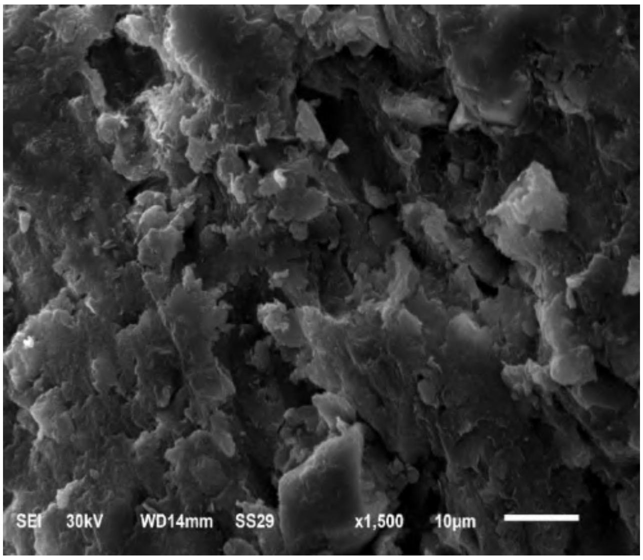


Fig.11. SEM micrograph of natural soil after artificial contamination with wastewaters (DW)

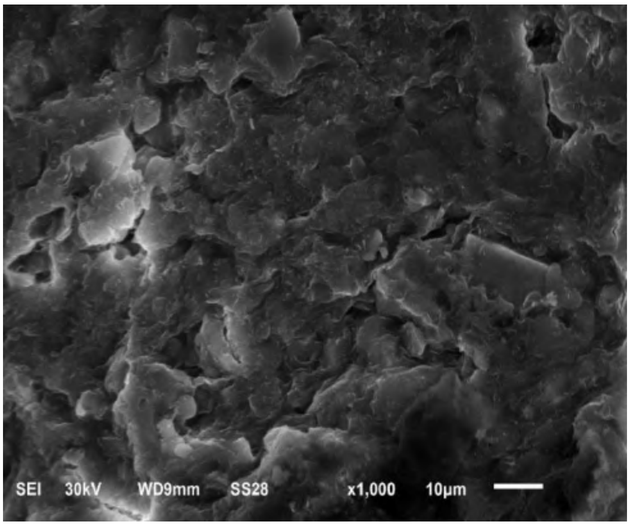


Fig.12. SEM micrograph of natural soil after artificial contamination with wastewaters (TW)

4.6 discussions and comparing results with other studies

The influence of the inorganic and organic pollutants of the dairy and textile wastewaters on fine-grained soils has been discussed in detail, especially with respect to the modes of mechanical, chemical, and mineralogical properties and microstructure of the studied soils. Further, the effect of the wastewater on the Atterberg limits and on the compaction and free swell of various fine-grained soils has also been critically assessed. Based on the above, the unique nature of the industrial wastewaters and their interactions have been highlighted and critical observations made.

Table 10, 11 contains the findings for the examined soils in this study. Table12 compares the findings of the previous studies with those of Kartika et al., (2021), Khodiry et al., (2018), Cyrus et al., (2010), and Baykuş, et al., (2021), Alnos Easa et al (2009), Kerman (2012), Girisken (2013). Considering this comparison, it is concluded that the effect of the dairy and textile wastewaters on fine-grained soils is significant which change the properties of natural soil. The optimal moisture content (O.M.C.) values for the current study are greater than the values for earlier investigations. However, compared to other investigations, the dry density values for the current study are lower.

Additionally, the range of specific gravity (Gs) values is the same for the past and contemporary studies. The present study's compaction test results are lower than those of earlier research. The examined soils in the current study didn't contain as much sand as those in earlier investigations. Variable values for silt and clay content are seen in both the current investigation and earlier studies. The percentage values for clay minerals in the current study and earlier investigations were very similar. The free swell (FS) values for the current study are higher than the values for the earlier studies. All soils were categorized in accordance with Unified Soil Classification System (USCS).

Table 10. *The experimental findings for the studied soils of the present study*

Property		**S1 (natural soil)**	**DW1 (2 month)**	**DW2 (4 month)**	**DW3 (6 month)**	**DW4 (8 month)**	**DW5 (12 month)**	**DW6 (16 month)**
O.W.C		20	22.5	22.75	23	23.5	24	24
Dry density		1.7	1.61	1.6	1.58	1.57	1.54	1.53
G. S		2.67	2.6	2.6	2.58	2.577	2.57	2.565
Atterberg limits	(L.L), %	74	66.5	65	64	63	62.5	62
	P.L	33	32	30	29	28	27	27
	S.L	18	19	20	21	Broken	Broken	Broken
	P.L	41	36.5	35	35	35	35	35
XRD Minerals percentage	Quartz	12.4	-	-	-	-	-	12.4
	Calcite	14	-	-	-	-	-	14
	Kaolinite	21.3	-	-	-	-	-	21.3
	albite	26.8	-	-	-	-	-	26.8
	Montmorillonite	25.5	-	-	-	-	-	25.5
Soil		MH	MH	MH	MH	CH	CH	CH
F.S, %		60	65	72.5	75	76	78	78

Table11. *The experimental findings for the studied soils of the present study*

Property		**TW1/DW1 (natural soil)**	**TW2 (2 month)**	**TW3 (4 month)**	**TW4 (6 month)**	**TW5 (8 month)**	**TW6 (12 month)**	**TW7 (16 month)**
O.W.C		20	21	22.25	23	24	24.25	25
Dry density		1.7	1.65	1.64	1.62	1.61	1.6	1.6
G. S		2.67	2.65	2.635	2.63	2.61	2.61	2.6
Atterberg limits	(L.L), %	74	62	62	62.5	63	63	63
	P.L	33	34.5	35	35.5	35	34	33
	S.L	18	19.2	20.5	20.5	broken	broken	broken
	P.L	41	27.5	27	27	28	29	30
	Quartz	11.5	-	-	-	-	-	11.5

XRD Minerals percentage	Calcite	16	-	-	-	-	-	16
	Kaolinite	20	-	-	-	-	-	20
	albite	22.5	-	-	-	-	-	22.5
	Montmorillonite	30	-	-	-	-	-	30
Soil		MH	MH	MH	MH	CH	CH	CH
F.S, %		60	70	72	75	76.5	77.5	79.5

Table12. The experimental findings for the studied soils of the present study

Property	**O.W.C**	**Dry density**	**G. S**	**Atterberg**	**limits**	**S.L**	**P.I**	**Clay (%)**	**Silt (%)**	**Sand (%)**	**F.S, %**
				L.L	**PL**						
Alnos Easa et al (2009)	23	1.94	2.72	48	25	16	23	22	70	8	60
Cyrus et al., (2010)	82	-	2.7	95	34	16	61	38	29	33	-
Girisken (2013)	19.4	1.62	2.67	29	25	4	-	--		-	40
Kermani (2012)	3.9	-	-	23.9	45.5		21.6	3	89	7	-
Karthika et al., (2021)	-	1.81	-	35.25	8.33	--	18.33				

V. CONCLUSION

Thirteen samples of confined soil were gathered from the case study region. Laboratory studies on these soil samples were performed to examine the physical traits of the various samples. In addition, the mineralogy of clay and the structure of soil particles were investigated using scanning electron microscopy and X-ray diffraction. The properties of both natural and contaminated soils that were gathered from the case study area were the subject of experimental research. The following conclusions are possible:

1) It has been suggested that the geotechnical properties of fine-grained soil promote the degradation of dairy and textile products, perhaps posing threats to the site's current construction.
2) The natural soil's liquid limit (LL) and plastic limit (PL) values were 74% and 34%, respectively. While the relative levels of contamination (LL and PL) of soil with dairy effluent are, respectively, 66.5% to 62% and 32% to 27%. The LL and PL of soil contaminated with textile wastewater ranged from 62% to 63% and 34.5% to 33%, respectively.
3) The optimum moisture content (O.M.C.) and dry density of natural soil were 20% and 1.70 gm/cm3, respectively, while these values ranged from 22.5% to 24% and 1.61to 1.53 gm/cm3 for soil that had been contaminated by dairy wastewater. When soil was contaminated with textile effluent, the O.M.C. and dry density were, respectively, 20.5% to 22.3% and 1.65 to 1.6 gm/cm3.
4) According to the Unified Soil Classification System (USCS), the soils in the case study area are categorized as MH. Additionally, the impact of soil contaminated by dairy wastewater was categorized as MH and CH. The soil that was contaminated with textile effluent, on the other hand, was categorized as CH and MH.
5) The specific gravity (SG) and shrinkage limit (SL) of natural soil were 18% and 2.67, respectively. While the specific gravity (SG) and SL of soil that has been contaminated with dairy effluent range from 2.6 to 2.56 and 19% to 21%, respectively. The specific gravity (GS)

and (SL) of soil contaminated with textile effluent were 2.65 to 2.6, and 19.2% to 20.5%respectively.

6) For the natural sample, the percentages of quartz, calcite, kaolinite, albite, and montmorillonite are 20.4%, 12.8%, 20.8%, 22.6and 23.4%, respectively. While these components changed with the addition of dairy wastewater. Therefore, the Quartz, Calcite, Kaolinite (K), albite (I) and montmorillonite percentage are changed to 12.4%, 14%, 21.3%, 26.8%, and 25.5%, respectively. On the other hand, the components of control soil changed with the addition of textile wastewater. Therefore, the Quartz, Calcite, Kaolinite (K), albite (I) and montmorillonite percentage are changed to 11.5%, 16%, 20%, 22.5%, and 30%, respectively. These results matched with the chemical composition of samples analyzed with XRF test.

7) The free swell (F.S.) values of natural soil had 60%. The results showed that contaminated soil with dairy wastewater has the higher than the control samples (78%), meanwhile contaminated soil with textile wastewater has the highest value (79.5%). It was also demonstrated that there is a direct correlation between free swell values and dry density, liquid limit, and plasticity index. This conclusion is also in line with what Sridhan (2000) and Sheahan (2011) found.

8) The microstructure of the examined soils shows that, in comparison to the control samples, the wastewater increased the morphology's porosity and looseness.

9) The engineering qualities of soil, particularly free swelling, are severely reduced by effluent from dairy and textile industries. Additionally, it is possible that the mineral particles would disintegrate, resulting in a loss of soil density. This loss of soil density can be identified as a significant Factor in the differences in soil parameters that were tested using SEM techniques.

10) The chemical properties of the soil, which also contribute to the definition of soil quality, control the status and activity of microbial populations. This study examined the effects of land filtration methods used for wastewater treatment and disposal in rural areas this study focused on how industrial wastewater affects the features on the chemical and physical properties of fine-grained soil.

REFERENCES

[1] Muhammad Irfan, Yulong Chen, Muhammad Ali, Muhammad Abrar, Ahmed Qadri and Osama Bhutta, 2018 Geotechnical properties of effluent - contaminated cohesive soils and their Stabilization using industrial by-products, Process Issue 6, No.203, pp 1-21

[2] Mitchell, J. Fundamentals of Soil Behavior; Wiley: New York, NY, USA, 1993.

[3] Gratchev, I.B.; Sassa, K. Cyclic behavior of fine-grained soils at different pH values. J. Geotech. Geoenviron. Eng. 2009, 135, 271–279.

[4] Terzaghi, K.; Peck, R.; Mesri, G. Soil Mechanics in Engineering Practice; John Wiley & Sons:New York, NY, USA, 1948.

[5] Sridharan, A.; Nagaraj, H. Plastic limit and compaction characteristics of fine-grained soils Proc. Inst. Civ. Eng. Ground Improv. 2005, 9, 17–22.

[6] Stalin, V.K.; Muthukumaran, K.; Kartikeyan, A. Effect of Liquid waste on the index and engineering behaviour of soils. In Proceedings of the Indian Geotechnical Conference: IGC-2000: The millennium conference, Mumbai, Indian, 13–15 December 2010; pp. 229–230.

[7] El-Kasaby, E.A. "Foundation on Swelling Clay", Master Science Thesis, Department of Civil Engineering, University of Assuit, Egypt, 166 pp., (1978).

[8] Easa, AA and El-darder, M.E. "In-Situ Investigation of Mineralogical and Chemical Properties of Clayey Soil Contaminated with Wastewater", Engineering research journal, Helwan University. vol. 84, pp. 150-161, (2002).

[9] ASTM D4318-17e1; Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils. ASTM International: West Conshohocken, PA, USA, 2017.

[10] AASHTO T90; Standard Method of Test for Determining the Plastic Limit and Plasticity Index of Soils. American Association of State Highway and Transportation Officials (AASHTO): Washington, DC, USA, 2020.

[11] Abd El-Latief, M. A., Ashour, M. B., & El-Tahrany, A. C. (2015). Strengthening of the permeability of sandy soil by different grouting materials for seepage reduction.

[12] BS EN ISO 17892-12:2018+A2:2022; Geotechnical Investigation and Testing. Laboratory Testing of Soil. Part 12: Determination of Liquid and Plastic Limits. British Standards Institution: London, UK, 2022.

[13] Barnes, G.E. The Plastic Limit and Workability of Soils. Ph.D. Thesis, University of Manchester, Manchester, UK, 2013.

[14] Easa, A., & Abou-Rayan, A. (2010). Domestic wastewater effect on the pollution of the groundwater in rural areas in Egypt. aquatic, 3(4), 5.

[15] Casagrande, A. Classification and identification of soils. Proc. Am. Soc. Civ. Eng. 1947, 73, 783–810.

[16] O'Kelly, B.C. Review of recent developments and understanding of Atterberg limits determinations. Geotechnics 2021, 1, 59–75.

[17] Baykuş, N., & Karpuzcu, M. (2021). The Effects of Wastewater on The Chemical and Physical Properties of Fine-grained Soils. Avrupa Bilim ve Teknoloji Dergisi, (31), 771-775..

[18] Sherwood, P.T. The Reproducibility of the Results of Soil Classification and Compaction Tests; Transport and Road Research Laboratories.

[19] El-Kasaby, E. A., Eissa, E. A., Ab-Elmeged, M. F., & Abo-Shark, A. A. (2019). Coefficient of Consolidation and

Volume Change for 3-D Consolidation. European Journal of Engineering and Technology Research, 4(5), 126-131.

[20] Cyrus S, Kumar TG, Abraham BM, Sridharan A, Jose BT (2010) Effect of industrial wastes on the physical and engineering properties of soils . Indian Geotechnical Conference GEOtrendz, pp 357–360

[21] El-kasaby, E.A. and El-Saadany, M.M. (1993) : ”Soil investigations report of old mosques”,El-Monofya state. Arab Engineering Consultants, Banha.

[22] El-kasaby, E.A. and El-Saadany , M.M. (1993) : ”Effect of circumstances surrounding foundations on safty of constructions”, 5th Arab Conf. on Stru. Eng. , Civil Eng. Dep. , Al-Fateh Univ., Tripoli, Libya.

[23] Crawford, C.B. and burn, K.N. (1992):”Settlement studies on the mt. Sinai hospital” Eng. Jornal of Canada, Ottawa, Vol. 345, No. 22.

[24] Roberts, M.H.; Roy, D.M. and Kumar (1990) :”Failer of buildings foundations on clay”, Proc. Asce, Vol. 217, PP. 853-859.

[25] Sherif, M.; Mashhowr, M. and shatter, M. (1986) : ”Influence of the chemical composition of pore fluid on consistency and compression characteristics of clay”, Journal of Egyptian Society of Engineers, Vol. 25, No. 4,PP. 9-16

[26] El-kasaby, E.A. and El-Saadany, M.M. and Easa,E.A. (1994):”Influence of waste water on physic-chemical properties and mineralogy of fine- grained soils” Second Conference on Civil Engineer, Military Technical College, Cairo, Vol. II, PP. 123-132

[27] El-kasaby, E.A. and El-Saadany, M.M. and Easa,E.A. (1995):”Influence of waste water on index properties of fine-grained soil” Frist Engineering Conference, Faculty of Eng. Mansoura Univ.,Mansoura, Vol III., PP 329-337.

[28] Bayoumy, S.M. (1988) : “ Effect of pollutions on its engineering properties “. M.SC.D. Thesis (Civil Eng.) Zagazig Univ., Egypt.

[29] Kirov, B. 1989. Influence of Waste water on Soil Deformation. Proc. of 12th ICSMFE-1989, Brazil, pp. 1881-1882.

[30] Srivastava, R.K., Singh, M., Singh, B. and Tiwari, R.P. 1992. Soil-Fluid (Fertilizer Plant Effluent) interaction behaviour. Indian Geotechnical Conference, Calcutta, India, pp. 501-504.

[31] Yaji, R. K., Gowda Ramakrishna and Jha, Sandeep 1996. Influence of contamination on the behaviour of shedi soil, IGC-1996, December 1-14, Madras, Volume 1, pp. 540-543.